SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASURED AT WASHINGTON, D. C., DURING JULY, 1915.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., Aug. 4, 1915.]

In Table 1 are summarized the measurements of the intensity of direct solar radiation made by the Weather Bureau at the American University,[1] Washington, D. C., during July, 1915. The means for the month are considerably lower than the 5-year means published in the Bulletin of the Mount Weather Observatory, 1912, 5:182, Table 3. On the 6th, 9th, and 18th, intensities very nearly in accord with these means were measured.

Skylight polarization, measured at solar distance 90° and in his vertical, with the sun at zenith distance 60°, averaged 45 per cent, with a maximum of 57 per cent on the 6th. This latter is the average maximum polarization for July for Washington, as published in the Bulletin of the Mount Weather Observatory, 1910, 3:114, Table 16.

In Table 2, column 2 gives the daily totals of solar and sky radiation received on a horizontal surface at the American University. The measurements were made with a Callendar recording pyrheliometer as described in the REVIEW for March, 1915, 43:100. Table 2, column 3, gives the daily departures from the normals published in the same number of the REVIEW, page 109, Table 4.

The "Percentage of possible sunshine" and the "Average cloudiness," given in columns 5 and 6 of Table 2, have been taken from the records of the observatory at the central office of the Weather Bureau.

While the above data show about the average number of hours of sunshine for July, the total radiation was below the average. The deficiency occurred in the second decade, however, as both the first and third decades show slightly more than the average amount of radiation.

TABLE 1.—*Solar radiation intensities at Washington, D. C., during July, 1915.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.3°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915. A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
July 6	1.39	1.23	1.11	1.03	0.95	0.88	0.81	0.74	0.66	......	......
9	1.36	1.27	1.16	1.07	1.00	......	......	......	......	......	......
17	......	1.04	0.78	0.74	......	......	......	......	......	......	......
18	1.35	1.17	1.04	0.94	......	......	......	......	......	......	......
19	0.99	0.82	0.72	0.64	0.56	......	......	......	......	......	......
21	......	1.01	0.84	0.77	......	......	......	......	......	......	......
22	......	1.03	0.89	0.76	0.66	0.57	0.50	0.45	0.42	......	......
24	1.16	......	......	......	......	......	......	......	......	......	......
25	1.08	0.95	0.86	......	......	......	......	......	......	......	......
26	......	......	0.73	......	......	......	......	......	......	......	......
Means	**1.22**	**1.06**	**0.90**	**0.85**	**0.79**	**(0.72)**	**(0.66)**	**(0.60)**	**(0.54)**	......	......
P. M.											
July 6	......	1.25	1.12	1.02	0.95	0.89	0.77	......	......	......	......
24	......	1.05	0.91	0.82	......	......	......	......	......	......	......
Means	......	**(1.15)**	**(1.02)**	**(0.92)**	**(0.95)**	**(0.89)**	**(0.77)**	......	......	......	......

[1] For a description of exposures of instruments and details of methods of observation, see this REVIEW, December, 1914, 42:648.

TABLE 2.—*Daily totals and departures of solar and sky radiation at Washington, D. C., during July, 1915.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily total.	Departure from normal.	Excess or deficiency since first of mouth.	Percentage of possible sunshine.	Average cloudiness.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Per cent.*	*0–10.*
July 1	592	68	68	78	4
2	547	22	90	70	6
3	430	−95	−5	60	8
4	458	−67	−72	43	9
5	372	−153	−225	39	8
6	767	242	17	100	0
7	581	57	74	77	6
8	367	−157	−83	43	7
9	758	235	152	100	1
10	534	12	164	64	8
11	337	−185	−21	22	9
12	481	−40	−61	52	7
13	594	74	13	73	5
14	640	120	133	90	5
15	356	−163	−30	24	9
16	366	−152	−182	38	8
17	439	−78	−260	54	5
18	655	139	−121	99	0
19	415	−99	−220	60	5
20	241	−272	−492	0	10
Decade departure	....	....	**−656**	....	....
July 21	528	17	−475	61	4
22	580	70	−405	79	4
23	563	55	−350	56	4
24	632	126	−224	99	3
25	629	124	−100	98	0
26	562	59	−41	96	3
27	518	17	−24	96	5
28	372	−127	−151	43	9
29	448	−49	−200	36	8
30	498	3	−197	65	5
31	549	55	−142	82	4
Decade departure	....	....	**350**	....	....
Total excess or deficiency since first of year	....	....	**−1,200**	....	....

NOTE ON THE DISTRIBUTION OF MOISTURE IN THE ATMOSPHERE.

By WM. R. BLAIR, Professor in Charge of Aerological Investigations.

[Dated: Weather Bureau, Washington, Aug. 3, 1915.]

In the Bulletin of the Mount Weather Observatory, volume 4, part 4, pages 194–197, the writer published tables of the absolute humidity, in grams per cubic meter, at different levels above sea. The weights are given to thousandths of a gram in these tables. The following statement is made on page 209 of the same volume: "It seems plausible that * * * the constituent, water vapor, will remain an important factor even at very high levels, etc." Since the publication of the above, inquiries have been received as to whether the accuracy of the observations, made in free balloon ascensions, justified the use of three decimal places in these tables. In answer to these inquiries it may be stated that the best proof we had at the time of the accuracy of the observations of relative humidity was the fact that, among themselves, the results of these observations are consistent. This evidence pointed to the fact that the weights obtained were qualitatively correct and were valuable in expressing the relative moisture content of the air at different levels or at different times. The expression of these relative values required the use of three decimal places in the tables. The use of at least three decimal places is also justified by the fact that at the higher levels reached the weight per cubic meter of dry air is comparatively small. When one is considering the depth of water that would result from the precipitation of all the atmospheric moisture above a given area of the earth's surface, it is usually true that the consideration of the moisture found in the higher levels has very little effect on the result. This point of view is useful when the absorption by the water vapor of the air of outgoing or incoming radiation is the subject of study. If one is thinking of the relative amounts by weight of water vapor and dry air at a given level and of the possible effect of this relation on the distribution of air temperature and on other atmospheric phenomena, the moisture found in the higher levels seems to assume very considerable importance. Table 1, based upon the results obtained in six summer and six winter balloon observations, gives some idea of this importance. The six summer ascensions used are those of September 1, 5, and 11, 1910, and July 23, 27, and 30, 1913. The six winter ascensions are those of February 9, 14, 15, 18, 25, and 26, 1911. The 1910 group of three ascensions were made at Huron, S. Dak., the 1913 group of three were made at Avalon, Santa Catalina Island, Cal.; the 1911 group of six were made at Fort Omaha, Nebr. This table shows the ratio of the weight of water to the weight of dry air at the different levels selected for computation. In getting the mean ratio for the six summer and the six winter observations, arithmetic means of the air temperature, air pressure, vapor pressure, and weight in grams per cubic meter of the air moisture were found for each level. Based upon the first three means the weight per cubic meter of dry air at a given level was determined. Comparison was then made between this weight and the third mean found above. The ratio has been determined for several of the ascensions separately. Of these the determinations for September 1, 1910, and for September 11, 1910, are tabulated as showing the extreme values of the ratio found in the upper levels.

The selection of observations for use in Table 1 was made with reference to altitude.

Sounding-balloon observations to a height of 25 or more kilometers are comparatively few in number either in this country or elsewhere. The indications of available data obtained in other countries are found to be similar to those of the data contained in Table 1.

It happened that during three observations of the 1913 series at Avalon, Mr. Fowle, of the Smithsonian Institution, was simultaneously observing spectroscopically the total amount of precipitable water in the atmosphere above Mount Wilson. The comparison of hygrometric and spectroscopic determinations of this depth is of especial interest here as indicating that the hygrometric determinations are of value in a quantitative as well as in a qualitative sense. The comparison is made in Table 2.

Table 1 indicates a minimum value for the ratio under consideration somewhere between the 10 and 15 kilometer levels for the observations considered. Above these levels the ratio may become greater than was found at any lower level.

In addition to answering questions that have arisen, it is thought that the facts of observation shown in Table 1 may be of interest in connection with the theory that has given rise to the terms "troposphere" and "stratosphere" for lower and upper regions of the atmosphere, which have been supposed to be so distinctly separated from each other that there is practically no mixing across the boundary plane between them of the air in one with the air in the other. This boundary plane has been placed at the supposed upper limit of convection, and consequently at the upper limit of a homogeneous mixture of the constituent gases of the atmosphere, and at the lower limit of a region in which there is no convection and in which constituent gases sort themselves under the influence of gravity. According to this theory, any moisture found in the stratosphere must have reached it by diffusion across the boundary plane from the supposedly moister air of the troposphere, and its quantity must therefore be small. On this supposition some relation should be found to exist between the vapor pressures in the two regions considered. It is not at all clear from the data that any such relation exists. Indeed these data point rather to the distribution of moisture in the usual way throughout the region explored; i. e., both by air movement and by diffusion.

TABLE I.—*Showing variation of the ratio,* $\frac{\text{Weight of } H_2O}{\text{Weight of dry air}} \times 10^6$, *with altitude.*

Altitude in kilometers	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	6	7	8	9	10	11
Means of observations made Sept. 1, 5, 11, 1910, and July 23, 27, 30, 1913	8,535	8,328	7,522	6,693	4,665	3,278	2,255	1,754	1,386	1,134	775	49	280	181	93	60
Means of observations made Feb. 9, 14, 15, 18, 25, 26, 1911	2,547	2,107	1,991	1,491	1,036	855	677	624	569	534	348	160	103	56	39	31
Observation of Sept. 1, 1910 (air of upper levels extremely dry)	11,268	11,600	10,524	8,373	4,983	2,085	742	351	207	214	164	106	61	36	14	8
Observation of Sept. 11, 1910 (air of upper levels extremely moist)	4,484	4,133	6,837	7,874	5,654	4,303	3,305	2,897	2,480	2,134	2,081	1,561	960	666	323	190

Altitude in kilometers	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Means of observations made Sept. 1, 5, 11, 1910, and July 23, 27, 30, 1913	49	35	41	48	50	51	75	106	124	196	285	542	1,039	1,697	....	....
Means of observations made Feb. 9, 14, 15, 18, 25, 26, 1911	33	42	44	43	42	48	49	57	78	92	[1] 137	[1] 142	[1] 164	....	....	....
Observation of Sept. 1, 1910 (air of upper levels extremely dry)	3	3	4	5	6	13	15	18	21	37	43	51	59	70	83	97
Observation of Sept. 11, 1910 (air of upper levels extremely moist)	120	80	137	195	233	216	363	521	659	911	1,442	2,808	5,712	9,553	....	....

[1] Observation of Feb. 25, 1911, only.

TABLE 2.

Date.	Balloon H_2O.	Spectroscopic H_2O.
	cm.	*cm.*
July 23, 1913	1.07	1.17
Aug. 3, 1913	1.41	1.39
Aug. 8, 1913	2.09	2.06